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Published in:
EPRINTS-BOOK-TITLE

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2005

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Kuipers, T. A. F. (2005). Problem reduction and its relevance. Reply to Thomas Nickles. In *EPRINTS-BOOK-TITLE*

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Theo A. F. Kuipers

PROBLEM REDUCTION AND ITS RELEVANCE

REPLY TO THOMAS NICKLES

The perspective of problem reduction, as presented by Thomas Nickles, is in many respects a stimulating way to look at my own work. I will mention a number of points, and elaborate two of them somewhat.

(1) I like Nickles' talk, in Section 1, about reduction on three levels, that of language, theory and method, and I agree about the foundering of far-reaching reduction programs regarding them. However, in SiS I try to show that modest reduction claims regarding concepts, laws and explanatory methods are very defensible (SiS, Ch. 5, 3, 4, respectively).

(2) With Kim (2000, p. 89, also quoted in SiS, p. 134), I regret very much that it is almost politically incorrect to use the term 'reduction' for evident successful cases. Perhaps Nickles' and Sintonen's convincing extension – if not focussing – the idea of reduction to the category of problems may help to re-establish the use of the term 'reduction' when relevant.

(3) Perhaps to Nickles' surprise, there is a direct link between problem reduction and truth approximation, *see below*.

(4) As Nickles points out at the end of Section 2, problem reductions may be based on logical equivalencies, which are epistemologically asymmetric. A special case is the transformation of problem representations. Below I indicate that the general phenomenon also occurs in philosophy and that the special case relates to aesthetic considerations.

(5) Nickles distinguishes in Section 3 the search space "as it really is (in something like Popper's Third World)" and "as the investigators conceive it to be." Although I feel affinity with Popper's Third World, I doubt whether it leaves room for a search space as it really is. With Newell and Simon, I think that the search space needs to be defined before we can sharply formulate a problem, let alone search for a solution. As ICR illustrates, even to explicate the idea of truth approximation we need to assume a domain and a vocabulary, for otherwise "the truth" is not defined.

In: R. Festa, A. Aliseda and J. Peijnenburg (eds.), *Cognitive Structures in Scientific Inquiry (Poznań Studies in the Philosophy of the Sciences and the Humanities, vol. 84)*, pp.134-137. Amsterdam/New York, NY: Rodopi, 2005.

(6) As will be clear from Ch. 12 of SiS, I am of course very happy with Nickles' appreciation of the semantic (or structuralist) interpretation of theories, as appears from his Section 6. However, in view of Nickles' critical discussion and my liberal usage of structuralist terminology in the rest of SiS and in ICR, it might be useful to formulate different degrees of structuralism. For it is one thing to view theorizing as primarily an attempt to represent (natural or artificial) systems in terms of (mathematical) structures, called models of the theory; it is another to suppose that the relevant classes of models can be set-theoretically axiomatized in the sense explicated by Suppes. It would be still more specific to think of a logical axiomatization in some formalized language, with a first order language, without a serious distinction between observational and theoretical terms, as the logical-empiricist ideal.

Problem Reduction and Truth Approximation

I cannot resist the temptation to quote the last paragraph of Section 1 of Nickles' paper in full:

As Sintonen notes, by focusing on problem reduction in the sciences, we also do more justice to scientific practice. One can argue that methodology of science itself is more properly pitched at this pragmatic level, on control-theoretic grounds. (Philosophers have often focused on issues such as the truth of theories that seem to have little controlling influence in actual scientific research, although they may be of philosophical interest.) But then it is especially incumbent upon those who pursue a problem-solving account of scientific inquiry to inquire into problems themselves and their relations to one another.

This paragraph can be seen as a perfect characterization of the two main messages of ICR. First, in line with Laudan (1977), both realists and instrumentalists try to improve the problem-solving merits of theories; that is, they use the instrumentalist rather than the falsificationist method. Second, however, *pace* Laudan, whether they like it or not, this method is functional for truth approximation. Of course, there are various ways of improving the problem-solving merits of theories, including various kinds of problem reduction. Hence, I read Nickles' contribution as a systematic and historical underpinning of (partial or complete) problem solving by problem reduction. In particular, his Section 4 documents this. However, Nickles is inclined to classify theory reduction, including law reduction, as something quite distinct from problem reduction, whereas in my view the successful reduction of a law by a theory (as analyzed in SiS, Section 3.3) is just *one* typical kind of problem reduction, for the theory, together with the relevant auxiliary hypotheses, explains the (domain of validity of the) law, that is, the law is a general success of the theory of a very special kind, even if the theory is false. Hence, in contrast to Nickles' suggestion at the end of Section 4, stressing the

importance of law reduction is not against a Laudan-like problem solving view and in favor of a confirmationist view or, I would like to add, a falsificationist view.

Problem Reduction Guided by Epistemological and Aesthetic Considerations

Problem reductions may be based on logical equivalencies, which are epistemologically asymmetric. This also occurs in philosophical matters. For example, in dealing with non-zero probabilities for universal generalizations, the epistemologically attractive but methodologically impracticable systems developed by Hintikka and Niiniluoto turned out to be equivalent to *prima facie* epistemologically dubious, but very practical systems (Kuipers 1978). Another example is the logical equivalence of three different formulations of or foundations for the same definition of truthlikeness: solely in terms of consequences of theories, solely in terms of models of theories, or partially in terms of consequences and partially in terms of models. As I argue in ICR (Ch. 8), the last one, the dual foundation, nicely fits the refined HD method for the evaluation of theories.

A special case of problem reduction by equivalencies is indeed that “a transformed representation can render a seemingly difficult problem trivial,” as Nickles illustrates with a well known chess board problem at the end of Section 2. There is even a straightforward link with beauty in science here, for such problem reductions are frequently mentioned as typically beautiful. As a matter of fact, in science we come across two kinds of beauty. We speak of the beauty of methods of proof and of problem solving on the one hand, and of results such as propositions, laws, theories, and truths on the other. The so-called diagonal proof of the non-denumerability of real numbers is an example of a method that strikes almost everyone for its simplicity and inventiveness. It typically reduces the problem by representing it in a very special way. In Kuipers (1991) I have collected ten examples of beautiful problem-solving methods for quite mundane problems such as the quest for the resulting concentration after mixing red and white wine twice in a certain way (see my reply to Van Bendegem). However, as suggested, solutions themselves may also be considered as beautiful, like new results in general. Moreover, regarding results themselves, we might distinguish between new results that are found beautiful because they are surprising, perhaps because they open new perspectives, and results that are found beautiful because they fit into the current “aesthetic canon,” a term introduced by McAllister (1996). In Kuipers (2002) I address the last type of aesthetic considerations (Thagard and Miller

comment on that paper, in this volume and the companion volume, respectively). It would be interesting to investigate the extent to which the “aesthetic canon” functions as a means of problem reduction, by stimulating the search for certain kinds of solutions of problems.

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